Levels of polybrominated diphenyl ethers (PBDEs) in eggs of Wisconsin cormorants

Tara L. Edblom
Environmental Toxicologist, EIM

Co-Investigators:
- Sean M. Strom (Principle Investigator) WM, WDNR
- Dr. Kenneth L. Stromborg, USFWS

Funding Source:
- USEPA Great Lakes National Program Office (GLNPO).....**$15,000**

Partner Agencies & Organizations:
- Bureau of Wildlife Management, WDNR
- U.S. Fish and Wildlife Service
- Wisconsin State Laboratory of Hygiene

Throughout history, fire has been a major cause of property damage and loss of life worldwide. In the United States alone, over 3 million fires are reported annually, resulting in 29,000 injuries, 4,500 deaths, and loss of property estimated at greater than $8 billion (Gann 1993). To help minimize the risk of fire, flame retardant chemicals have been developed that reduce the likelihood of ignition and burning. Among these flame retardant chemicals are the polybrominated diphenyl ethers (PBDEs), which have been used extensively over the past two decades as flame retardants in textiles, plastics, furniture, electronic circuitry, and a variety of other products.

Around the world, PBDEs have been detected in both marine and freshwater fish-eating birds, marine mammals, shellfish and sediments, cod liver, herring, and freshwater eels (de Boer 1989; Jansson et al. 1987; Watanabe et al. 1987; Stafford 1983). In the Great Lakes, PBDEs have been identified in several species of fish, including salmon, which showed concentrations among the highest known in the world for these fish in open waters (Manchester-Neesvig et al. 2001). PBDEs have also been detected in Wisconsin sport fish consumers.

The biological effects of PBDEs have not been well studied to date; however, the limited information

available suggests their adverse effects may be similar to those of the well-studied PCBs, including the potential to cause cancer and negative impacts on thyroid function, reproductive systems, and neurobehavior (McDonald 2002).

During the 1970s, double-crested cormorants were nearly extirpated from the Great Lakes, largely due to reproductive failure from eggshell thinning caused by dichlorodiphenyl-trichloroethane (DDT) (Peakall 1988). Since that time, the use of DDT has been banned, concentrations in tissues and eggs have decreased, and populations have increased (Scharf & Shugart 1981). Despite these increases, there remains concern that other bioaccumulative contaminants, including PBDEs, could pose risks to piscivorous wildlife.

Objectives: The purpose of this project is to obtain basic information on concentrations of PBDEs in eggs of Wisconsin cormorants from several Great Lakes sites. Because halogenated organic compounds, like PBDEs, are known to pass from mother to offspring, eggs can be used to detect their presence and provide an indication of relative environmental levels. In addition, we will determine spatial or temporal patterns that might exist in PBDE concentrations in eggs and compare those patterns with historic PCB concentration patterns.

Methods: We will collect eggs from sites located within the Great Lakes region that support double-crested cormorants and from which there are archived eggs collected in previous years (1980s and 1990s) by the U.S. Fish and Wildlife Service (USFWS). In spring 2003, upon initiation of breeding, we will collect eggs at the following locations: 1) Spider Island, Lake Michigan; 2) Cat Island, lower Green Bay; 3) Mead Wildlife Area, central Wisconsin (an inland comparison site). If possible, we will also collect eggs at Gull Island in the Apostle Islands National Lakeshore in Lake Superior. Six to eight eggs (one egg per nest) will be collected in a random fashion from each location by walking through the colony and taking eggs from the nest. We will also randomly select a total of 16 to 24 eggs from the USFWS archived collection.

Eggs will be processed according to USFWS protocol. Briefly, for each egg collected, basic measurements will be recorded (whole wt., length, width, volume). The egg will then be opened and the state of embryonic development recorded. The contents of the egg will be placed into a chemically clean jar and kept frozen at -20 °C until laboratory analysis. The Wisconsin State Laboratory of Hygiene in Madison, Wisconsin will analyze individual eggs for the following PBDE congeners:

1.	BDE #28	(2,4,4'-triBDE)	CAS # 41318-75-6
2.	BDE #47	(2,2',4,4'-tetraBDE)	CAS # 5436-43-1
3.	BDE #66	(2,3',4,4'-tetraBDE)	CAS # 187084-61-5
4.	BDE #85	(2,2',3,4,4'-pentaBDE)	CAS # 182346-21-0
5.	BDE #99	(2,2',4,4',5-pentaBDE)	CAS # 60348-60-9
6.	BDE #100	(2,2',4,4',6-pentaBDE)	CAS # 189084-64-8
7.	BDE #138	(2,2',3,4,4',5'-hexaBDE)	CAS # 182677-30-1
8.	BDE #153	(2,2',4,4',5,5'-hexaBDE)	CAS # 68631-49-2
9.	BDE #154	(2,2',4,4',5,6'-hexaBDE)	CAS # 207122-15-4

Data will be entered into a SYSTAT data set for summary statistics and any further statistical analysis as deemed appropriate (SPSS Inc., Chicago, IL). Sample size, normality or lack of normality, missing data, outliers and other factors will be taken into consideration when choosing which statistical tests are appropriate. We will quantify total PBDEs (sum of congeners) in cormorant eggs from each site. We will use analysis of variance (ANOVA) to test for differences in total PBDE concentrations among sites. In addition, we will examine PBDE congener profiles for samples from the different sites. This may provide insight into the original source of PBDE contamination, as the major PBDE technical products are comprised of certain PBDE congeners. We will also investigate and report temporal trends in PBDE concentrations, including calculations of doubling times if appropriate.

Upcoming Products: The results of the proposed research will be shared with the scientific community through presentations at professional meetings including the Society for Environmental Toxicology and Chemistry (SETAC) and others as travel funds allow. We will also publish our research results in an appropriate peer-reviewed journal. Data will be submitted to WDNR's Aquatic and Terrestrial Resources Inventory (ATRI).

Management Applications: Double-crested cormorant numbers in the Great Lakes have rebounded from near extirpation in the 1970's. However, biologists have remained concerned about the presence of deformed embryos and hatchlings reported in cormorants and other colonial nesting waterbirds. Developmental abnormalities are rare in free-ranging birds (usually $<1\%$) and may be local indicators that pollutants other than DDT are present in the Great Lakes ecosystem at biologically significant concentrations. PBDE concentrations are known to be present at high levels in biota around the world, including the Great Lakes. Though their negative impacts are largely unknown, it is prudent to gather more data which may help demonstrate that the concern is valid and so that actions can be taken to protect the health of Great Lakes wildlife.

Timeline:

2003 – Collect eggs from field sites and select eggs from archived collection. Process eggs and conduct laboratory analysis. Submit progress report to GLNPO.

2004 – Data entry, review and analysis. Summarize preliminary results and submit progress report to GLNPO. Complete final report. Present results at professional conferences.

2005 – Submit paper to a peer-reviewed journal for publication.

Literature Cited:

de Boer, J. 1989. Organochlorine compounds and bromodiphenylethers in livers of Atlantic cod (*Gadus morhua*) from the North Sea. *Chemosphere* 18:2131-2140.

Gann, R.G. 1993. Flame retardants: Overview, fourth ed. Kirk-Othmer Encyclopedia of Chemical

Technology, vol. 10. Wiley, New York, pp. 930-936.

Jansson, B., L. Asplund, and M. Olsson. 1987. Brominated flame retardants - ubiquitous environmental pollutants? *Chemosphere* 16:2343-2349.

Manchester-Neesvig. J. B., K. Valters, and W.C. Sonzogni. 2001. Comparison of polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs) in Lake Michigan Salmonids. *Environ Sci Technol* 35:1072-1077.

McDonald, T.A. 2002. A perspective on the potential health risks of PBDEs. *Chemosphere* 46:745-755.

Stafford, C.J. 1983. Halogenated diphenyl ethers identified in avian tissues and eggs by GC/MS. *Chemosphere* 12:1487-1495.

Peakall, D.B. 1988. Known effects of pollutants in fish-eating birds in the Great Lakes of North America. *In* N.W. Schmidtke, ed., Toxic contamination in large lakes. Vol. I – Chronic effects of toxic contaminants in large lakes. Lewis, Chelsea, MI. USA. pp.39-54.

Scharf, W.C., and G.W. Shugart. 1981. Recent increases in double-crested cormorants in the U.S. Great Lakes. *Am Birds* 35:910-911.

Watanabe, I., T. Kashimoto, and R. Tatsukawa. 1987. Polybrominated biphenylethers in marine fish, shellfish and river and marine sediments in Japan. *Chemosphere* 16:2389-2396.